Vol. XXXIV. *January, 1918.* *No. 1.*

BIOLOGICAL BULLETIN

AUTOTOMY OF THE TAIL IN RODENTS.

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It is perhaps not generally known that certain species of small rodents detach portions of the tail in a seemingly voluntary manner when they are seized by this member. Among the mouse-like rodents of California such an autotomy of the tail appears to be most typically exhibited by the pocket-mice (*Perognathus*).

It is the general practice of the writers, as probably of most breeders of mice, to pick up their animals by the tail. This appendage constitutes a convenient handle by which a mouse may be lifted, commonly relieving one of the risk of being bitten. But such a procedure is hazardous in the case of *Perognathus*. By a sudden gyratory movement of the body, the tail is likely to be severed at some point in its length, allowing the animal to make its escape and giving the pursuer something of a handicap in the race.

The whole performance is so suggestive of what occurs in many lizards that the question naturally arose in our minds: Can it be possible that autotomy, in the one case, as in the other, is followed by regeneration? This of course was not to be expected in a mammal, but the experiment seemed at least worth trying. In any case, the act and its consequences were thought to be worthy of a brief consideration.

The species upon which most of these observations were conducted was a rather large pocket-mouse, *Perognathus fallax fallax* Merriam, which is very common in the neighborhood of La Jolla. Despite the frequency of autotomy in this species, we soon found that all individuals cannot be depended upon to "perform" when desired. Those, in particular, which have been kept captive for some time seem to lose the tendency. More-

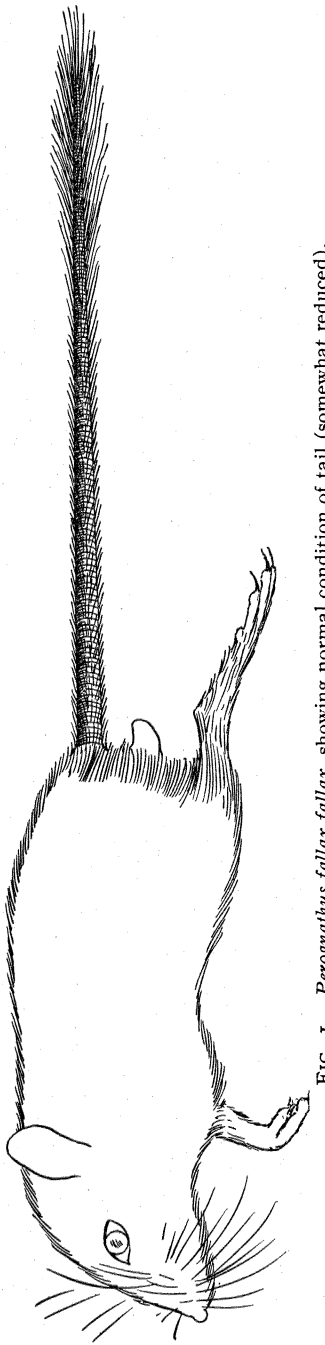

FIG. 1. *Perognathus fallax fallax*, showing normal condition of tail (somewhat reduced).

over, the act, when it does occur, is so sudden that one is commonly left wondering how it happened. But it was watched rather carefully in a number of instances, in order that the movements might be noted In some cases, the body seemed to undergo a rapid whirling motion, comparable with that of a rope tied at one end to a post and held by the hand at the other. The snout and tail, in this comparison, correspond to the points of attachment, the hind quarters of the body to the whirling central portion of the rope. A number of individuals which did not actually detach the tail were found to undergo less violent gyrations of the same sort. In other instances, however, there seemed to be an actual torsion of the appendage, resulting from a rotation of the body. In yet another, where the tail was held down upon a cement floor, the detachment was effected by a sudden leap.

In eight cases, in which the detached portions of the appendage were carefully examined, it was found that the fracture invariably occurred across one of the caudal vertebræ, commonly near its center. The tail is likely to be broken at almost any point in its length. The detached portion carries away with it a group of tendons of such length as to indicate that these have their points of origin within the body

itself. The possibility of a regeneration of the missing part of the tail was tested in fourteen specimens. Some of these underwent a voluntary autotomy, in the manner above described. In others, the breaking of the appendage was facilitated by the observer. These mice were all nearly mature, though probably most of them had not reached the limit of growth.

In the first seven specimens, the stump of the tail was measured shortly after the operation, but the length of the body was unfortunately not taken. Four of these specimens were living at the end of twelve months. In three cases, the tail has undergone a slight elongation (1–5 mm.), but this was doubtless merely an ordinary process of growth, accompanying the general growth of the body. In the fourth case, the recorded growth was 18 mm., though we believe this to be based upon an error in the first measurement. Except for the hair conditions, to be described below, there was no evidence of restoration of any part of the tail.

The next seven specimens were dealt with much more carefully. The length of the detached portion of the appendage was determined; likewise that of the stump, and the length of the body from the snout to the base of the tail.[1] Six of this second lot of mice were living at the end of nine months. When measured then, it was found that the tail stumps in five specimens had undergone a trivial increase in length, averaging about two millimeters. This was evidently incidental to a slight general growth of the body, since the mean body length, during the interval, had increased about four millimeters. In the sixth specimen, the tail was actually shorter, its condition indicating that it had been further damaged after the original operation.

Examination of the tissues of the tail in all of the foregoing specimens gave no suggestion of regenerative processes. In each case, the vertebral column terminated in a partial vertebra, this being evidently the one which was fractured in the process of autotomy.

There was, however, one very interesting result. In most of the specimens a dense tuft of elongated hairs had formed at the termination of the stump, the solid core of the latter being in

[1] In making the latter measurements the animal was etherized.

some instances enlarged at the end. This tuft was entirely a new growth, since the middle region of the tail is normally covered with very short hair. As the uninjured tail of this rodent terminates in a "pencil" or tuft of longer hairs (Fig. 1) the formation of such a tuft at the point of amputation gave the appearance of a restorative process. There are, however, considerable points of difference between the normal "pencil" and the secondary one. The former is produced by the gradual elongation of the hair which covers the tail, commencing with the posterior third or half of this member. The restored tuft (Fig. 2) commences much more abruptly, sometimes being

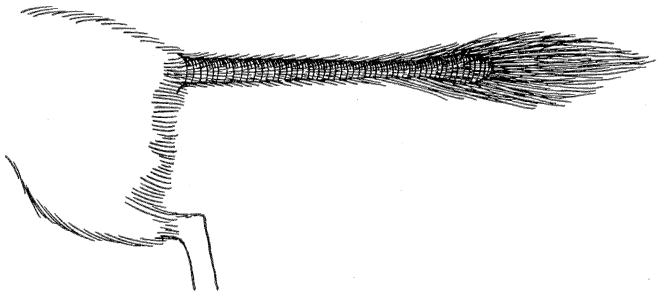

FIG. 2. Tail which has undergone autotomy about midway in its length, and upon which a new terminal tuft of hair has been produced.

confined to the end of the stump. Its hairs are much longer than those of the natural pencil, and their pigmentation is conspicuously decreased, being pale gray on the normally black dorsal side.

In two instances a small lateral tuft was likewise formed, not far from the end of the stump. In one of these cases, there was found to be an internal injury, corresponding in position to this lateral tuft.

The capture of two wild specimens with truncated tails indicates that this accident may not be uncommon in nature. There was, of course, no clue to the source of the injury. Both specimens had developed terminal tufts, one of these being unusually perfect.

The time required for the formation of a new "pencil" has not been definitely noted. We have record of its having arisen within two months, but we also know that more than four months may be necessary.

The writers offer no speculations as to the physico-chemical factors which bring about this excessive growth of the hair on the severed stump of the tail of *Perognathus*. A superficial analogy suggests itself between this terminal tuft and the cluster of adventitious shoots which arise from the stump of a tree. Possibly the analogy is more than superficial.

How general this process of autotomy is among the pocket-mice we can not say. We have noted its occurrence in only one other species, *P. panamintinus bangsi*, a small desert form in which the process is closely similar to that in *P. fallax*.

To what extent this phenomenon may be spoken of as a "protective adaptation," and whether or not it arose through natural selection, we are unwilling to conjecture. It is more than possible that a pursuing carnivore would sometimes be cheated of its prey in this manner, since the greatly elongated tail might readily be seized by the claws or teeth. The association between the fragile structure of this appendage and the peculiar instinctive responses of the animal is probably not accidental.

A phenomenon similar to that discussed above, but differing in essential features, has been observed by one of us in a species of *Peromyscus* (*P. boylei rowleyi*). This mouse likewise has a relatively long tail, and undergoes, when this member is seized, very much the same curious gyrations as does *Perognathus*. In the former species, however, the vertebræ are not broken, nor indeed is the central axis of the tail severed at all. The skin breaks at some point in its length, and slips off, leaving in one's hands the long tubular sheath which covered the appendage. This process is of such frequent occurrence as to be quite characteristic of these mice, which thus contrast strongly with the various other species of *Peromyscus* that we have observed. In the subspecies of *P. maniculatus*, for example, we have never observed the detachment of any portion of the tail or of the skin, in the course of handling several thousands of these animals. Nor have we observed it in any other genus of California Muridæ.

In *Peromyscus boylei rowleyi* we must again note what seems to be a significant correlation between structure and behavior. The skin of the tail breaks and slips off with remarkable facility.

Likewise, the animal, when seized by this member, makes what appear like vigorous and well-directed efforts to accomplish the severance. In *P. maniculatus*, on the other hand, the skin is far less easily detached, and the animal has scarcely ever been observed to undergo either bodily gyrations or torsion of the tail.

To what extent this detachment of the skin is to be regarded as an "adaptive mechanism," which has arisen because of its utility, we regard it as futile to discuss at present. A single observation may be cited, which, however, can not be regarded as throwing much light on the matter. One specimen of *P. boylei rowleyi* was caught by the tail in a spring mouse-trap, the body being uninjured. Under these conditions, the animal was unable to escape by slipping off the skin and died of shock or exposure. On the other hand, it must be stated that a considerable proportion of the living mice of this species which were lifted by the tail underwent this mutilation, in spite of considerable care being taken to prevent it. What happens to the exposed portion of the tail after the detachment of the skin, has not been observed. It probably dies and falls off.

SCRIPPS INSTITUTION FOR BIOLOGICAL RESEARCH,
August 8, 1917.